Low frequency surface plasmons on periodic semiconductor structures

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Surface plasmon polaritons SPPs are electromagnetic waves coupled to the oscillation of free charges on the surface of a metal. The large electromagnetic field at the metal surface and the possibility to guide waves beyond the diffraction limit has lead to an extraordinary interest in the field of surface plasmon optics or plasmonics [1]. This research has focused mainly at optical and near-infrared frequencies. The huge permittivity of metals at low frequencies (THz and microwaves) leads to weakly bounded SPPs to the surface, limiting the usefulness of low frequency plasmonics. We have recently demonstrated that this limitation can be easily overcome by using doped semiconductors instead of metals [2]. Semiconductors have a permittivity at low frequencies similar to that of metals in the visible, thereby making possible to excite and propagate low frequency SPPs.

We have investigated experimentally and theoretically the transmission of SPPs through gratings of grooves structured in doped Si with different doping concentrations. For the experiments we use THz time-domain spectroscopy, a technique that allows the direct measure of the amplitude and the phase of ultrashort THz pulses. From the analysis of the amplitude we see that Bragg scattering of SPPs by the periodic structure leads to the formation of a stop-gap, or a frequency range where the transmission is virtually suppressed. From the phase analysis important information such as the phase and the group velocities of the SPPs can be obtained. We observe a strong reduction of the group velocity at the edge of the stop gap due to the resonant scattering.

[1] W.L. Barnes, A. Dereux, and T.W. Ebbesen, *Surface plasmon subwavelength optics*, Nature **424**, 824 (2003).

[2] J. Gómez Rivas, M. Kuttge, P. Haring Bolivar, H. Kurz and J.A. Sánchez-Gil, *Propagation of surface plasmon polaritons on semiconductor gratings*, Phys. Rev. Lett. **93**, 256804 (2004).